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# Modelling Porous Ferroelectrics to Assess Piezoelectric Energy Harvesting Capabilities

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**Aim:** To evaluate the effect of porosity and porous structure on the energy harvesting capabilities of ferroelectric ceramics using a Finite Element Modelling approach.

## Context

Porous piezoelectric ceramics are of interest for energy harvesting applications due to porosity causing significant reductions in permittivity,  $\epsilon_{33}$ , compared with relatively small reductions in longitudinal strain coefficient,  $d_{33}$ , leading to increases in energy harvesting figures of merit, where  $FOM_{33} = d_{33}^2/\epsilon_{33}$  [1]. The development of an FE Model will allow different porous structures to be evaluated for their energy harvesting capabilities.

## Pre- and Post-Poling Porous BaTiO<sub>3</sub> network

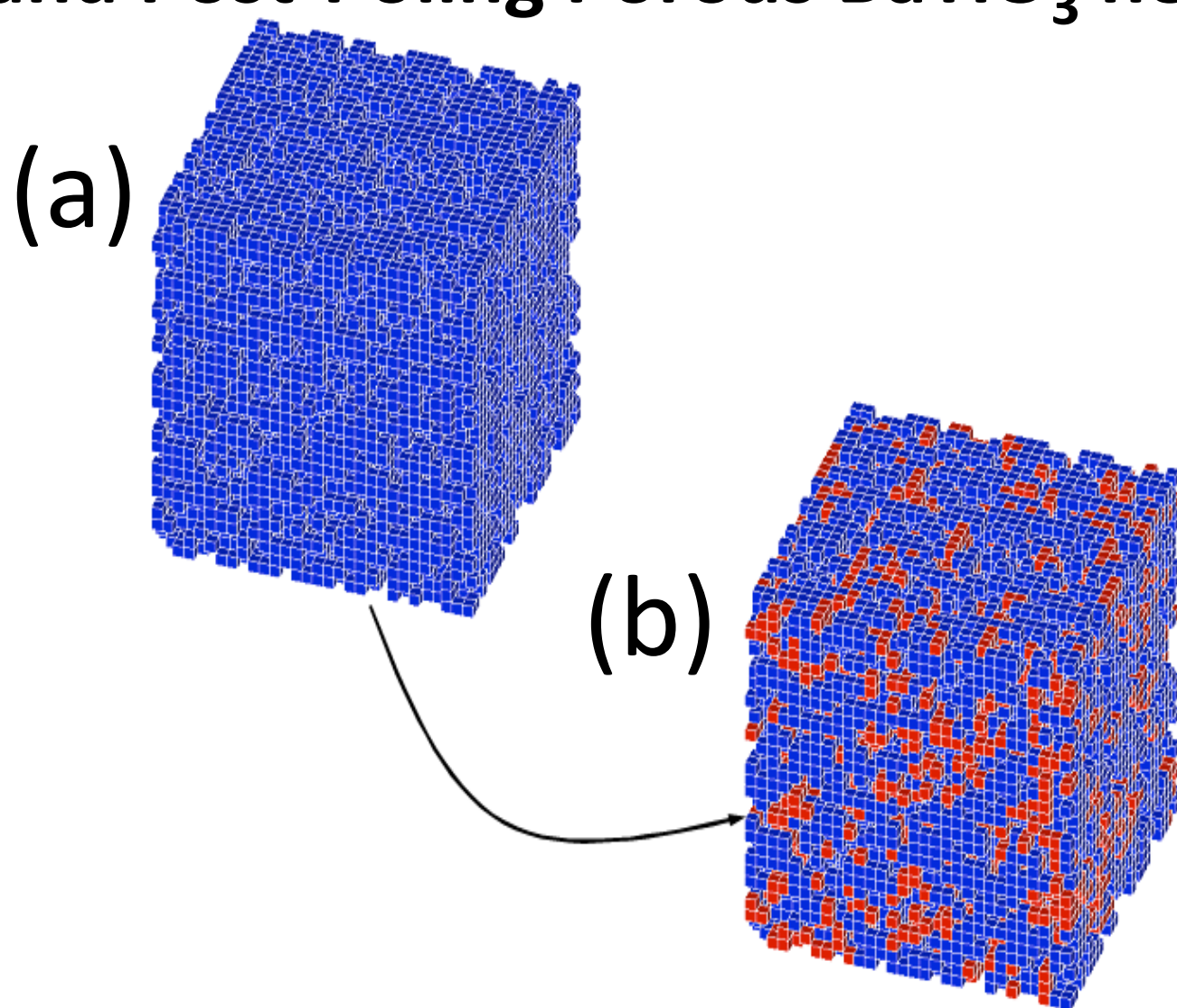


Fig. 1: (a)  $30^3$  cells randomly designated material properties of either unpoled BaTiO<sub>3</sub> (blue) or air (empty), depending of density defined for run and (b) post-poling procedure with poled (red) and unpoled BaTiO<sub>3</sub> (blue) and air (empty). BaTiO<sub>3</sub> elements are poled when local E-field exceeds coercive field.

## FE Modelling Process

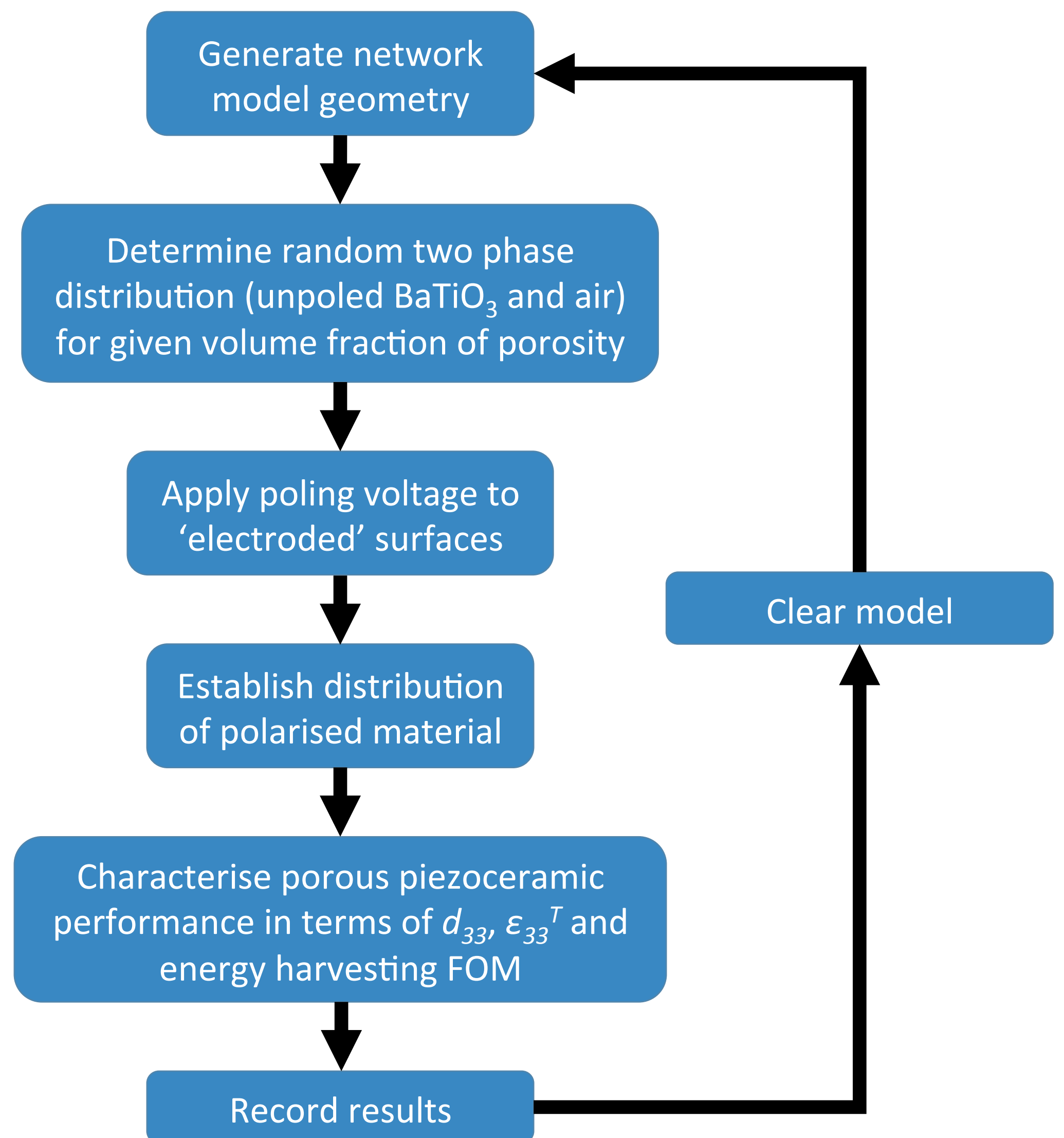


Fig. 2: Flow diagram of modelling process used to generate randomly distributed porosity with piezoelectric ceramic (adapted from [2])

## Initial Results

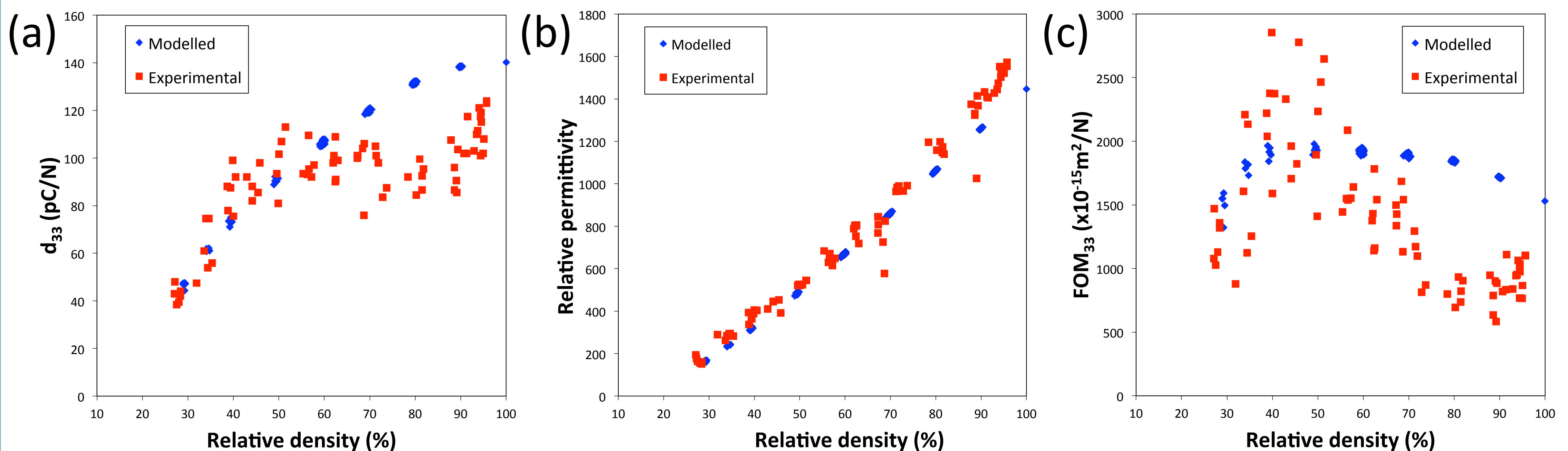


Fig. 3: FE model data (blue) compared to experimental data BaTiO<sub>3</sub> (red) for (a)  $d_{33}$ , (b) relative permittivity and (c)  $FOM_{33}$ , all plotted as a function of relative density. Experimental data measured from BaTiO<sub>3</sub> ceramics with range of porosities obtained using the burned out polymer spheres (BURPS) process.

## Discussion & Outlook

- Want to bring model and experimental data closer together
  - More accurate input data required
- Use model to investigate EH capabilities of different structures/connectivities
  - Currently, only randomly distributed porosity (3-0/3-3) generated
  - Structure has effect on key properties, i.e.  $d_{33}$ ,  $\epsilon_{33}$  and  $S^E_{33}$  (elastic compliance)

## Acknowledgement

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## References

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- [2] Lewis, R. W. C., Dent, A. C. E., Stevens, R., & Bowen, C. R. (2011). *Smart Mater. and Struct.*, 2011, **20**, 085002.